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TOWER FOR SEPARATING AND REMOVING ENTRAINED WATER AND MIST FROM A GASEOUS-FLUID MEDIUM.

NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA

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DEPARTMENT OF THE NAVY
U. S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE
WARMINSTER, PA. 18974

Aero-Electronic Technology Department

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TOWER FOR SEPARATING AND REMOVING ENTRAINED WATER AND MIST FROM A GASEOUS-FLUID MEDIUM

PHASE REPORT
AIRTASK NO. A31533507/2021/R008-03-01
Work Unit No. 3

A water separator has been developed for eliminating entrained water and mist from cooling air provided by ground cooling carts and other air sources.

Reported by: B. T. Plizak
B. T. Plizak
Development Support Division

Approved by: E R Mullen
E. R. Mullen, Superintendent
Development Support Division

D W Mackiernan
D. W. Mackiernan
Technical Director

S U M M A R Y

INTRODUCTION

To prevent internal corrosion and arc-over due to dielectric failure of direct air-cooled equipment, entrained water and mist must be effectively eliminated from cooling air with minimum back pressure to the source of air supply. Ground cooling carts operating in hot, humid environments such as Florida, the Mediterranean Sea, South China Seas, Vietnam, etc., produce large quantities of raw or free entrained-water in the cooling air by cooling the air below its dew point temperature. When the feed air line from the ground cooling cart has no water separator or an inefficient water separator connected to it, raw entrained water is permitted to pass over electronic component parts for equipments designed for direct blast cooling. This results in degradation of the electronic equipment by corrosion, arc-over, and dielectric failure.

SUMMARY OF RESULTS

Two versions of a tower water separator were designed, developed, and evaluated for use with a source of high airflow rate such as provided by ground cooling carts used with naval aircraft.

Laboratory tests were performed on tower water separators with porous foam sections in a parallel configuration and with porous foam sections in a series-parallel configuration. The foam sections were made of open pore polyurethane foam material. Tests were run at airflow rates from 5 to 25 lb/min with a water entrainment of 0.047 lb water/lb dry air (330 grains). There was no discernible entrained water present in the air stream exiting from the separator for either of the two configurations. Drain air losses covored a range from 5 to 14 percent for the drain sizes used in the parallel configuration. For the same drain sizes used in the series-parallel configuration, the drain air losses covered a range from 5 to 15.5 percent. The corrected pressure drop across the entire separator in the wet condition varied from 0.17 in. of water at 5 lb/min airflow to 4.50 in. of water at 25 lb/min airflow into the water separator for the parallel configuration; and, from 0.37 in. of water at 5 lb/min airflow to 9.5 in. of water at 25 lb/min airflow into the water separator for the series-parallel configuration. All data were extrapolated to 70 lb/min airflow into the water separator for both configurations. As expected, drain losses and pressure characteristics of the series-parallel configuration was higher than for the parallel configuration.

Tests were also performed on the parallel unit using an expansion turbine system. With this system the water separator began to pass small traces of fine water particles when a flow rate of approximately 30 lb/min was reached. The results of this test prompted the redesign of this unit to a series-parallel foam configuration to increase water separation efficiency at higher airflow rates. Return of turbine testing facilities, on loan from a ground cooling cart contractor, precluded further tests on this unit.

CONCLUSIONS

From the overall test results, it is concluded that:

1. The tower water separators designed, developed, and evaluated at NAVAIRDEVCEN will reduce or eliminate entrained moisture problems when used in conjunction with ground cooling carts operating in hot areas of high humidity such as Florida, the Mediterranean Sea, Vietnam, South China Seas, etc.

2. The units will aid in increasing the overall reliability of aircraft electronic equipment of the direct forced-cooled (blast cooled) type by reducing or eliminating equipment failures due to raw entrained water during ground operation.

3. The tower separator can effectively remove and eliminate raw entrained water from any source of high airflow rate.

4. Air losses from the separator can be held to a minimum by varying the size of the drain holes for any given inlet, airflow, foam pore size, and inlet pressure.

5. The tower water separators will operate more efficiently and with lower back pressure than existing water separators used with ground cooling carts in the range of flow rates used in these tests.

RECOMMENDATIONS

It is recommended that the tower water separators be utilized for effective elimination of raw entrained moisture from high flow (to 40 lb/min) cooling air sources such as refrigeration ground cooling carts used with naval aircraft. This is especially true for hot areas of high humidity such as Sanford, Florida, Vietnam, South China Seas, Mediterranean Sea, etc., where the cooling air is cooled below its dew point temperature.

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GENERAL DISCUSSION

BACKGROUND

The water separator study was initiated because of complaints from fleet activities to provide efficient water separators for ground cooling carts exhibiting raw entrained water in the cooling air being provided to aircraft electronic systems.

The entrained water in the cooling air has an adverse effect on equipments designed for direct or blast cooling where the cooling air passes directly over component parts. The result is corrosion, dielectric failures, and arc-over with consequent failure of the electronic equipment. Water entrainment in the cooling airstream is produced when the refrigeration ground cooling cart is operated in a hot, humid environment. Atmospheric air is taken into the ground cooling cart. Here it is cooled below its dew point temperature and increased in static pressure. This causes condensation of free water which becomes entrained in the cooling airstream. When the free water is not effectively removed, it is carried through the cooling air ducts to all units requiring air cooling. Conventional commercial water separators, usually of cloth-coalescer and centrifugal or rotational types, are presently used with ground cooling carts. These types of water separators exhibit a maximum water separation effectiveness of about 75 percent, and they operate at high pressure heads. Under high ambient humidity conditions (high dew point) and at high air-flow rates, there remains, in the airstream, a considerable quantity of free entrained water even with 75 percent water removal.

The purpose of this project was to provide a more effective means of separating and removing entrained mist and water particles from a high-flow airstream with minimum back pressure (pressure drop).

TOWER WATER SEPARATOR DEVELOPMENT AND DESCRIPTION

The NAVAIRDEVCEN tower water separator was developed for use with sources of high airflow, such as refrigeration ground cooling cart units used for cooling naval aircraft. It was designed to effectively remove entrained mist and water particles with minimum back pressure from the conditioned air supply.

Figures 1 through 7 show the internal airflo aths through the water separator. The separator incorporates open-pore polyurethane foam[1,2], (see appendix A) manufactured by Scott Foam Division of Scott Paper Company, in the sections acting as entrained water coalescers and strippers.

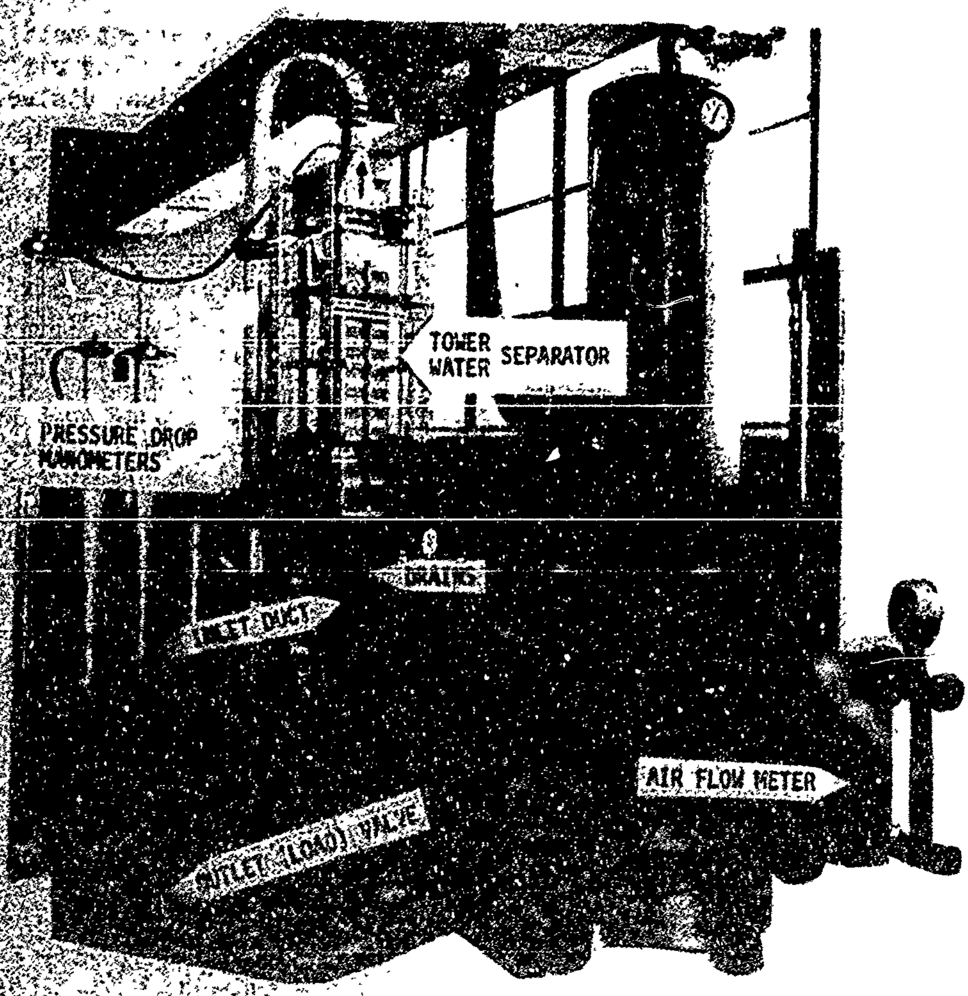

FIGURE 1 - NAVAIRDEVCEN Laboratory Test Installation, Overall View

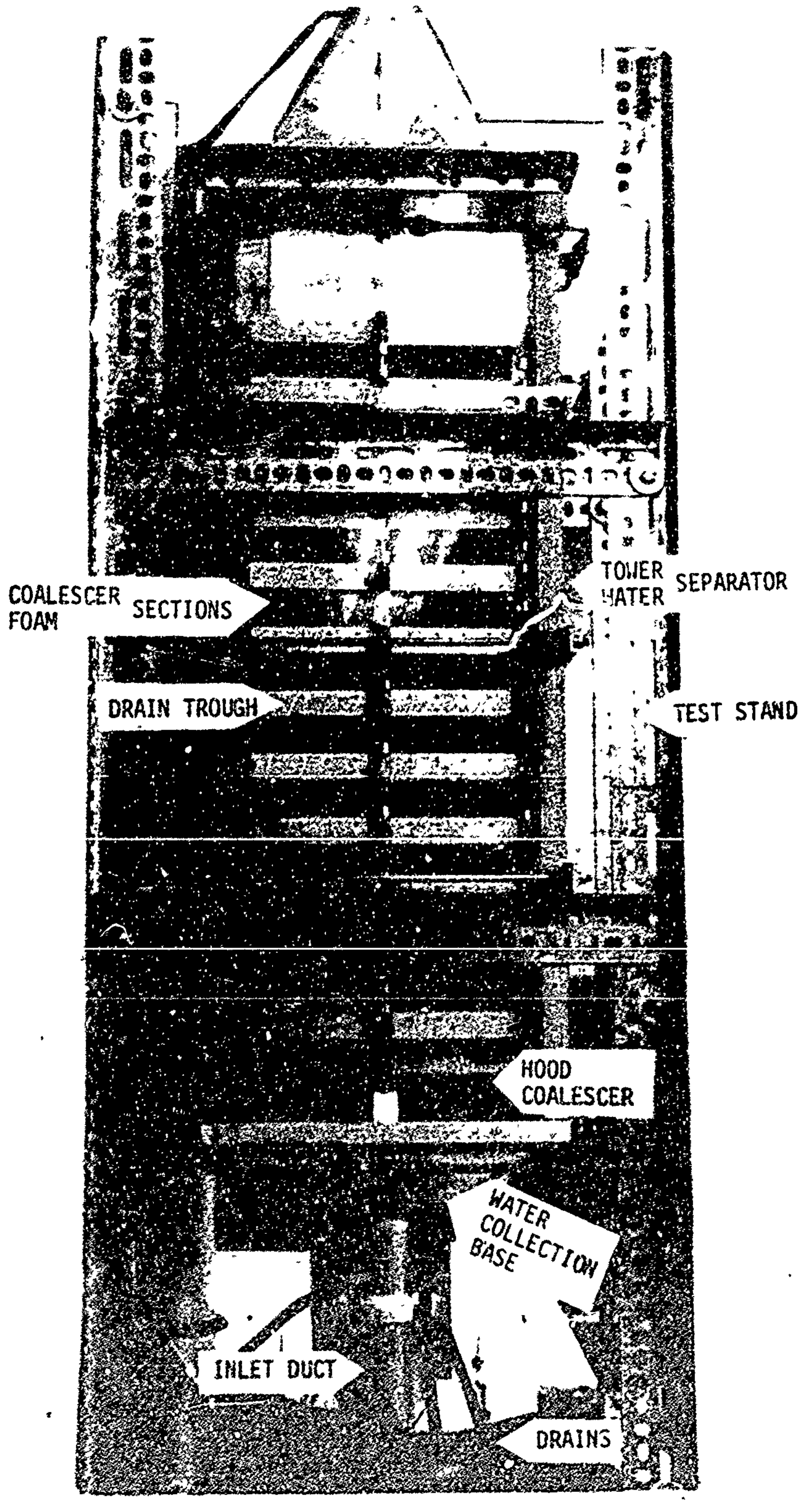

FIGURE 2 - Water Separator in a Dry Condition (Parallel), Front View

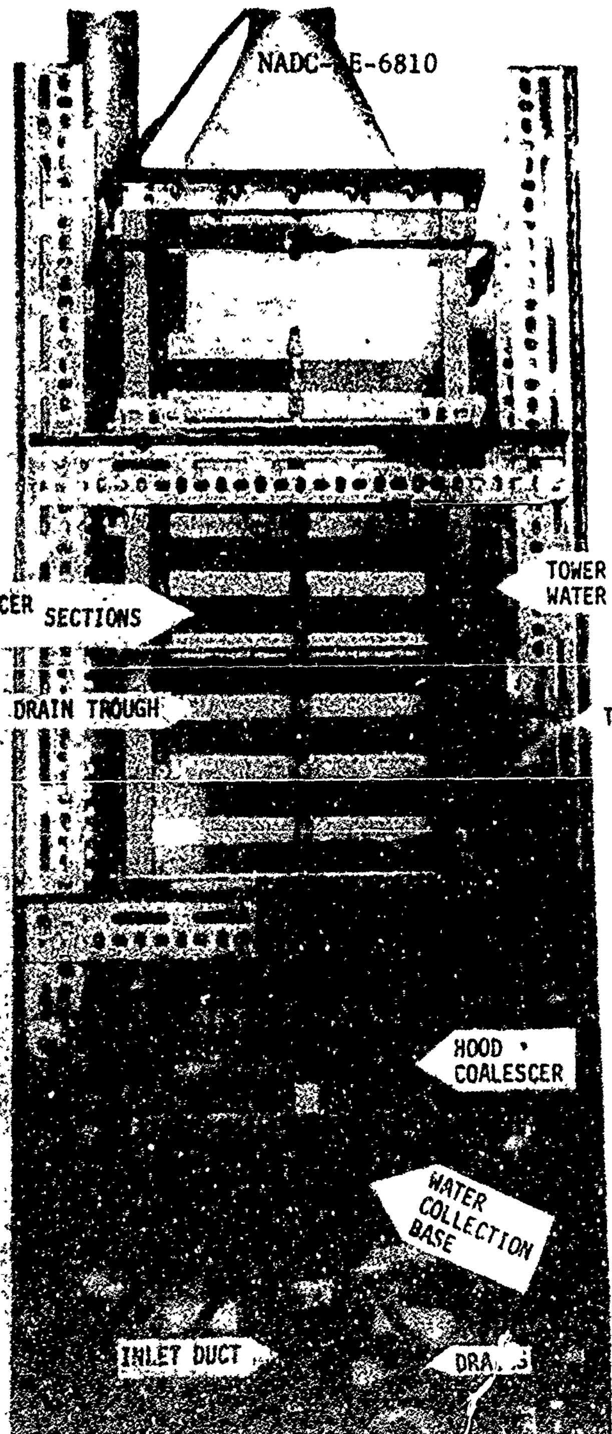

FIGURE 3 - Water Separator Operating in Wet Condition (Parallel), Front View

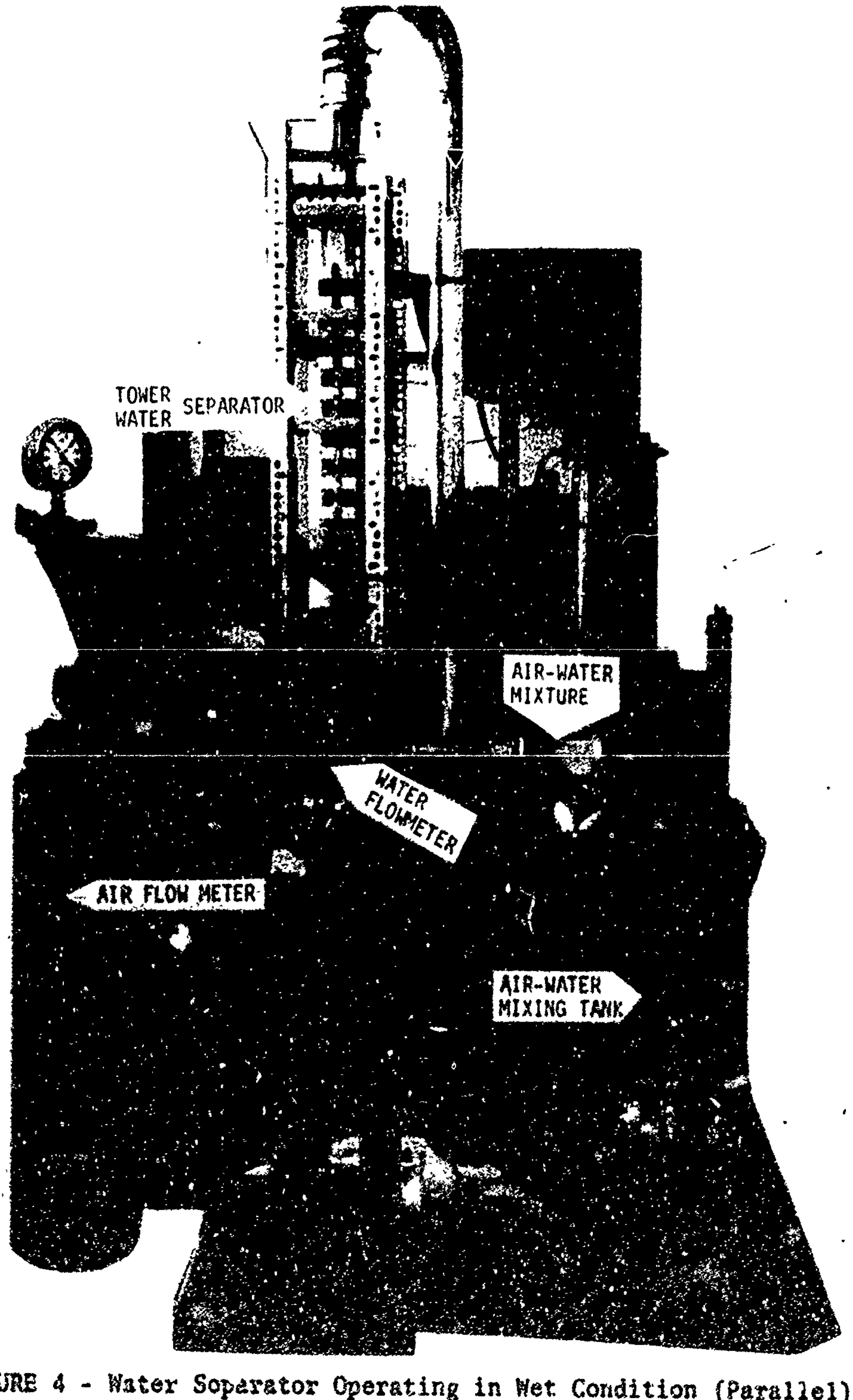

FIGURE 4 - Water Separator Operating in Wet Condition (Parallel), Side View

FIGURE 5 - NAVAIRDEVCEN Field Test Installation, Overall View

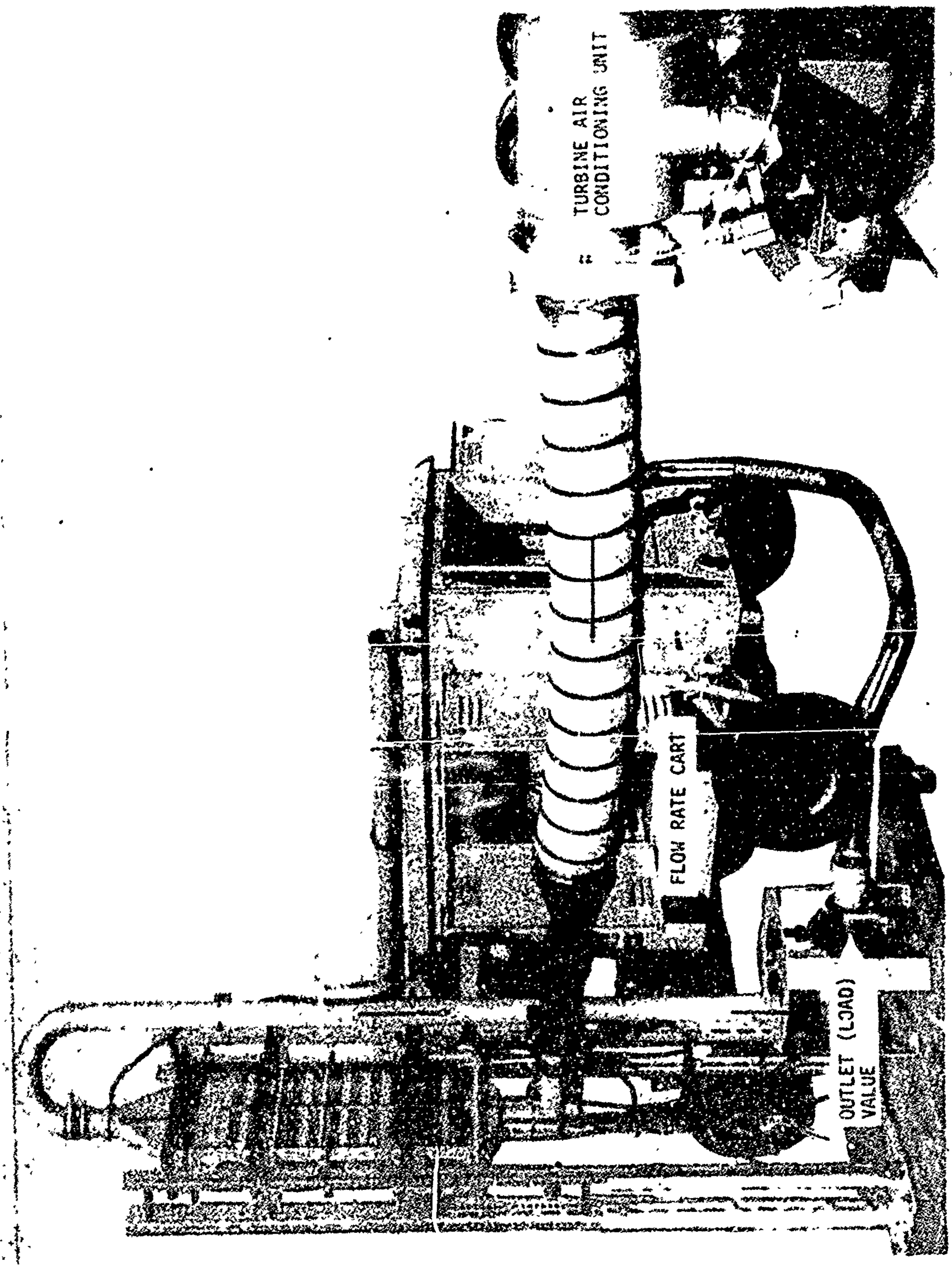

FIGURE 6 - NAVAIRDEVCEN Field Test Installation, Front View Closeup